PVs at Ekurhuleni

When life gives you lemons, make lemonade!

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A Bit About Us

- The City of Ekurhuleni is one of the South African Metropoles
- The word e-kur-hu-leni means “place of peace”
- In terms of electrical size, it eclipses the City of Johannesburg
- The City has a population of about 2,8 million

City of Ekurhuleni

- Arriving in South Africa, you will land safely at The OR Tambo International airport
- Situated within the boundaries of the City of Ekurhuleni

“EKURHULENI” MEANS PLACE OF PEACE…

BUT WE HAVE OUR CHALLENGES…

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CHALLENGES IN RELATION TO ENERGY

- The City has a sizable backlog in electricity supply connections
- Formal households awaiting connections total 120 000
- Informal households awaiting connections add a further 120 000
  - Many of these informal houses are in areas where soil conditions prevent development, e.g. dolomitic ground
  - Some informal housing structures were built on private land, meaning that they will have to be relocated
  - The ad hoc layout of an informal settlement is not conducive for safe and effective grid installation
  - By the very nature of these settlements, the electricity supplier will need to pay special attention to preventing grid interference (theft, etc.)
  - A National tariff structure exists to assist vulnerable customers, and the low levels of this tariff create sustainability difficulties for some distributors
  - The Eskom generation capacity is constrained and will remain so for the near future
  - Off-grid solar power packs are distributed by the City, with a small PV panel, a battery pack, LED lighting and a cellular phone charger
  - This alleviates the energy pressure somewhat, but more is needed, so that basic requirements such as keeping food cold, and watching television can be met.

Informal settlements in South Africa

ILLEGAL CONNECTIONS
ELECTRICITY NETWORK AND METERING INTERFERENCE
JULY 2014

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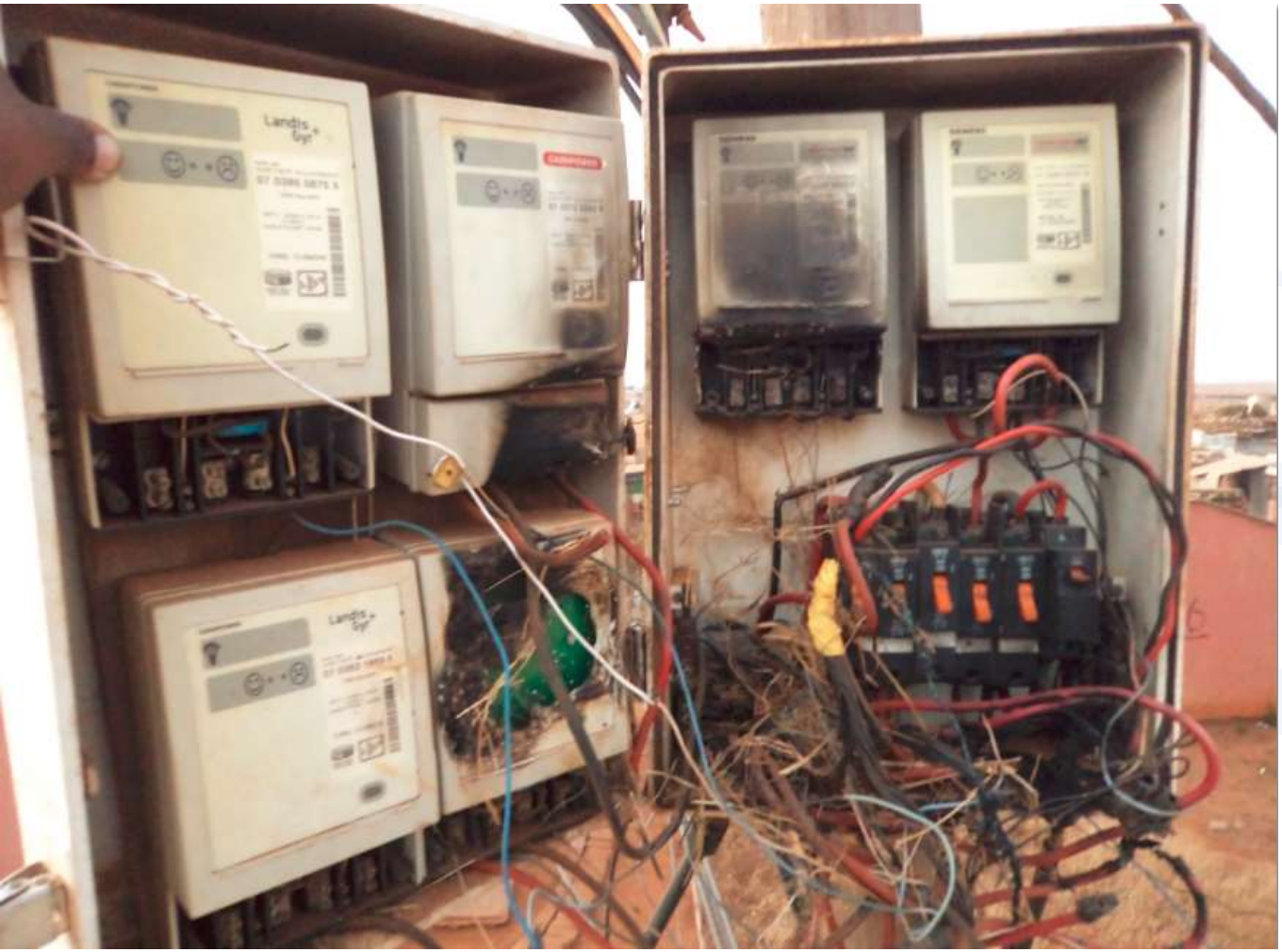
VANDALISM AND THEFT



- The photo was taken in Villa Liza x2, Boksburg
- 6 prepayment meters in one pole top box, all bypassed, at least 4 meters destroyed
- The uncontrolled electricity consumption destroys transformer and cable insulation, even to the point that they catch fire

ENVISAGED SOLUTION For Smaller Customers

- The challenges highlighted could be largely resolved by opting for an off-grid solar solution:
  - Solar energy is the only viable solution in Ekurhuleni, given low wind conditions and the topography
  - Provided that the capital input costs are within reason, the solar option could resolve all of the matters mentioned previously

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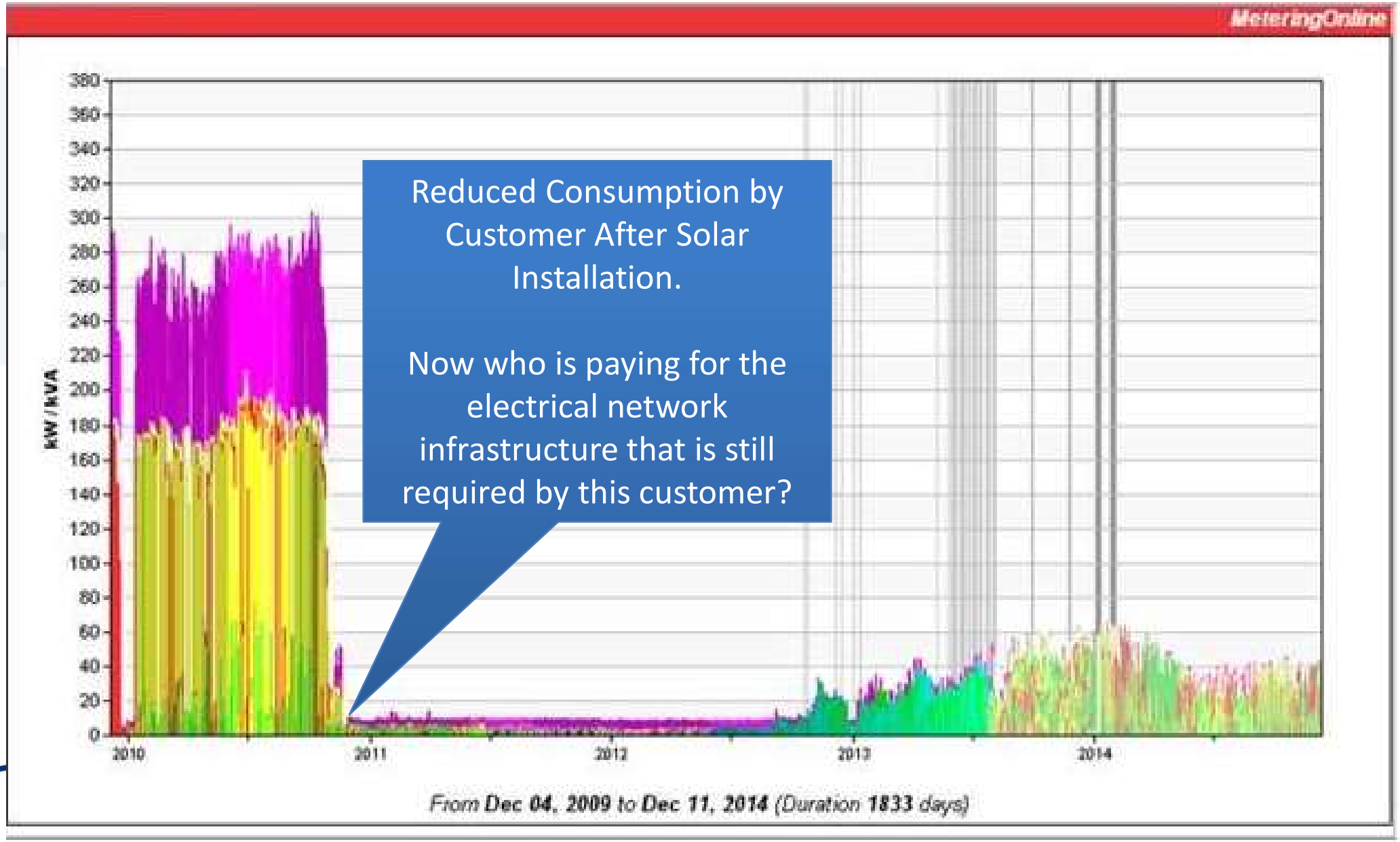
PV For Larger Customers Offers a Few Challenges - Business

- Distributed renewable generation is increasingly eroding EMM's energy revenue stream and power quality
  - PVs are being attached to the system on an ad hoc basis
  - Microgrids introduce the question of franchise rights and the definition of a utility
  - EMM's electrical network is be used as an uninterruptible power supply
  - Costs for dealing with PV and microgrid problems are indirectly being pushed on to customers not receiving benefits

Business Challenge –Paying for Infrastructure With Reduced Consumption



PV For Larger Customers Offers a Few Challenges - Technical

- Power System planning (steady-state and dynamics)
- Accurate forecasting of both generation resources & load
- Voltage stability (managing reactive power)
- Power balancing – sensitivity to the intermittent nature of renewable load, and matching base-load and peak-load generation, considering generator ramp rates and minimizing start-stop operation of peak-load generators.
- Overcoming the power balancing “reaction time mismatch” with energy storage solutions.
- EMM is having to maintain and operate the infrastructure to provide a reliable power supply
    - Relaying, reclosers, conductors and transformers to accommodate two-way power flows

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PV Energy Contribution Over 4 Days

Typical load profile : Commercial Customer

- Note Reverse Energy (-kWh)

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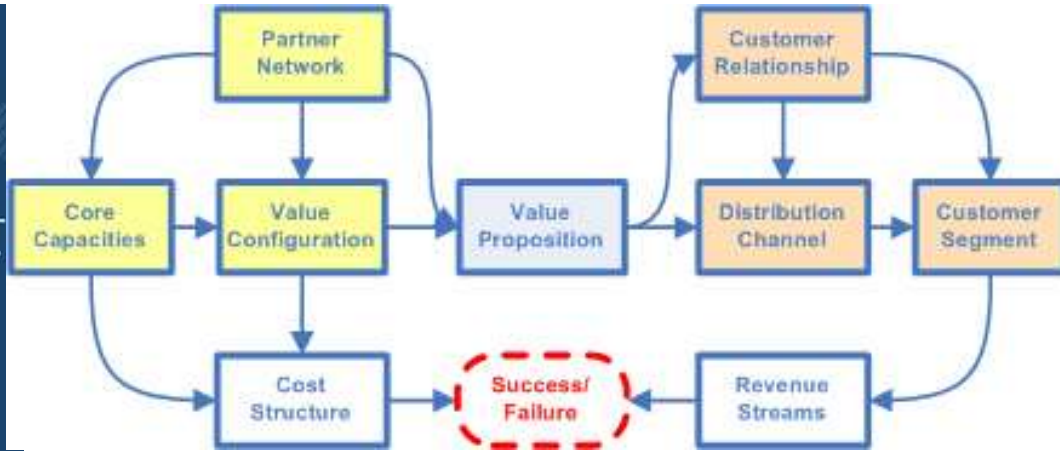
Ekurhuleni System Load Peaks at Varying Times Between 9 AM and 6 PM

Being Proactive with PV

- The American Council on Renewable Energy's 2014 Industry Review: "Evolving Business Models for Renewable Energy:"
  - Creates disruptive change for electric power utilities
  - Provides customers with alternatives to their utility
- Utilities must rethink how these distributed resources will affect their operations, planning, strategy and customer engagement. They must take proactive steps to:
  1. Renew the regulatory compact
  2. Market, test, or pilot alternative resources
  3. Define adjustments to the operating model
  4. Define adjustments to the business model



PV's Impact on Business

- While exact timing is difficult to predict, it is evident that Ekurhuleni will be dealing with industry disruptive technologies
- Ekurhuleni needs to be prepared to incrementally revise its energy sales business model and ensure it is supported by a flexible automation infrastructure
- The highest priority is the implementation of advanced metering infrastructure (AMI) as this would help Ekurhuleni to:
  - Have quicker response times for outages and other network problems
  - Enable the utilization of time-of-use and dynamic tariffs to provide consumers with financial incentives to reduce their electricity usage during peak demand times
  - Improve system reliability
  - Provide extensive data that can be used for planning purposes and to increase system efficiencies
- AMI needs to be implemented within a 20 year Smart Grid context
  - Implement AMI within a Smart Grid Integration Framework (SGIF) that is "future proof"
    - open industry standards (with particular attention paid to data management)
  - Give Ekurhuleni and its stakeholder information key to optimally adjust its business model

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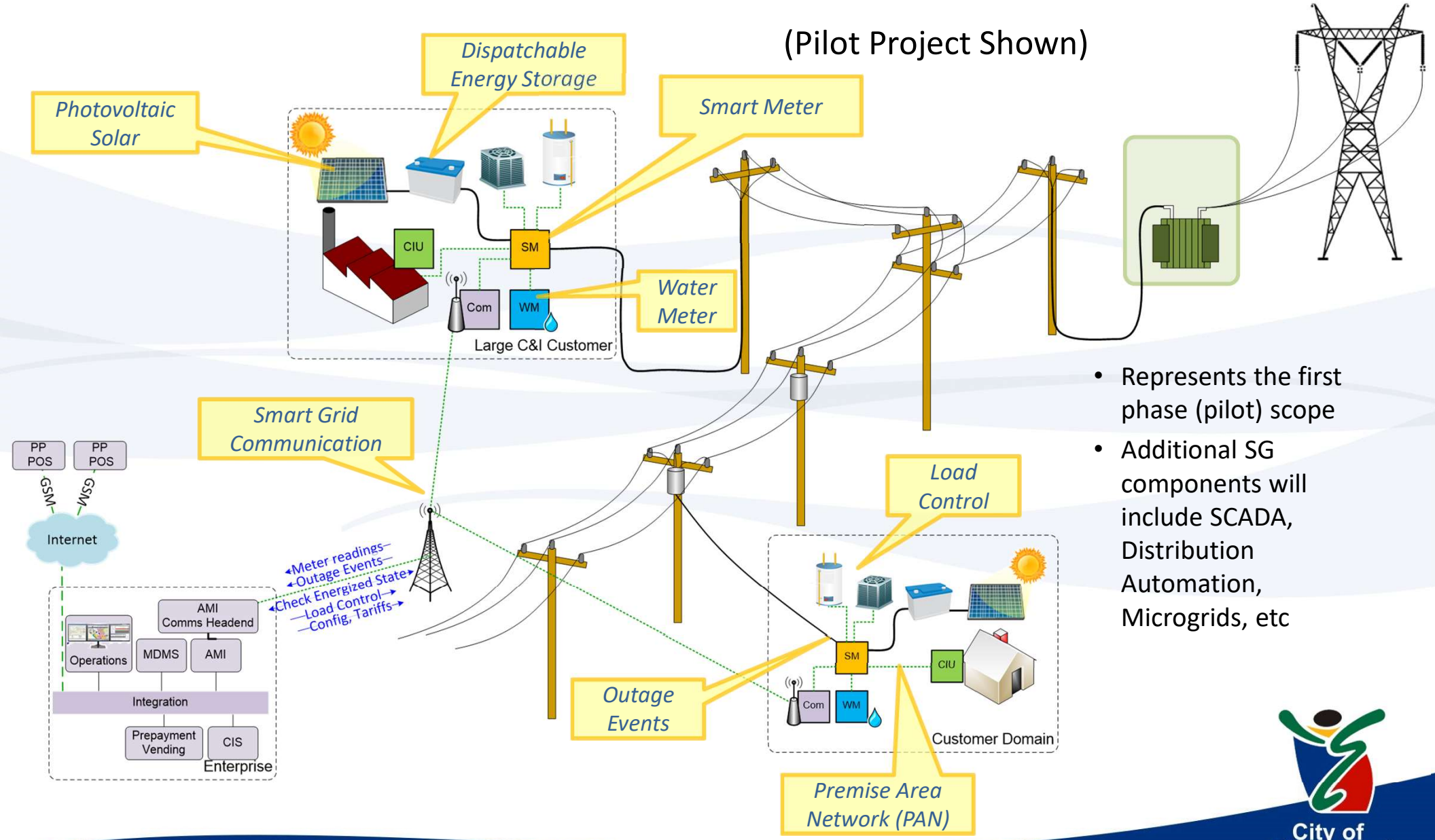
What is a Smart Grid ?

(Pilot Project Shown)



- Represents the first phase (pilot) scope
- Additional SG components will include SCADA, Distribution Automation, Microgrids, etc

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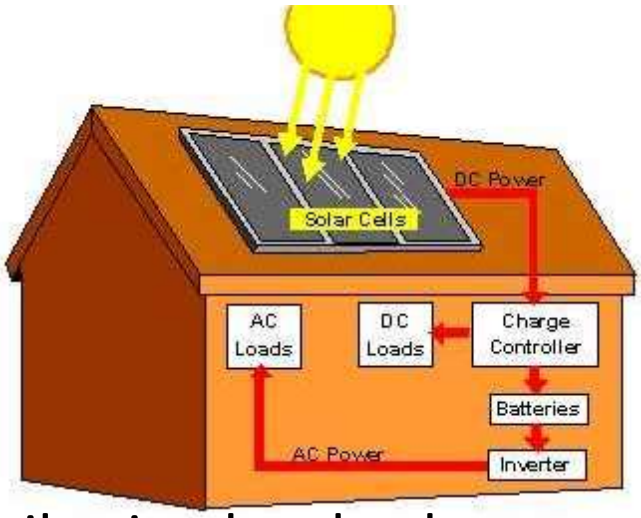
Smart Grid Planning with PV

- EMM developed an industry standards-based Smart Grid Roadmap in 2014
  - First step: piloting not only AMI capabilities, but also tariffs that can support a sustainable business model
  - Tariffs must be mutually beneficial to the municipality and its stakeholders
  - For PV customers with significant storage capabilities, there is the opportunity for them to work collaboratively with EMM
    - Their inverter capabilities can be integrated into system operations so that distributed energy resources are transformed from problematic uncertainties to beneficial tools for EMM's distribution management, providing ancillary services at the distribution level.

A Solution Component: Incentivizing Controllable Inverters



- PVs are often connected to the grid at the distribution level, where their presence in large scale or volume would be disruptive if not designed, integrated, and managed properly.
- Leverage inverters (the power converter circuits that integrate solar PV and battery resources to the grid) as they have:
  - Fast power controls and no inherent inertia such that they can respond quickly to commands and local conditions
  - Substantial processing and memory resources and are capable of supporting a variety of communication protocols and advanced functions
- Expose inverter capabilities and integrate them into utility system operations
  - Doing so will facilitate changing PVs from problematic uncertainties to beneficial tools for distribution management

A Solution Component: Incentivizing Dispatchable Storage

- Energy storage is seen as the current “holy grail” in the electric energy domain.
  - The ability to store energy in an economic, reliable and safe way and have it available for dispatch to the grid would greatly facilitate the operation of power systems and the integration of renewable energy sources at large scale
  - To date high costs and technology limitations have been a barrier to large-scale implementations.
- Energy storage would have a significant positive impact on renewable energy source integration:
  - frequency regulation
  - spinning reserve
  - peak load shifting or shaving

A Solution Component: Incentivizing Dispatchable Microgrids

- Microgrid systems would be most beneficial to Ekurhuleni stakeholders when their microgrid management system/controller operates in coordination with an overarching Ekurhuleni DMS.
  - The microgrid controllers provide real-time monitoring and control functions for all of the components within their control boundaries.
  - The local microgrid controller controls individual components of the microgrid:
    - load controllers
    - energy storage controllers
    - microgneration source controllers.
  - Their main objective is to ensure power reliability and quality.
- An overall master of multiple microgrid systems allows for optimizing the overall microgrids under its control.
  - It defines set points for all the loads and generation in order to optimize the efficiency of the microgrid depending on the electricity prices and local generation cost.
  - It also provides forecast and real-time estimation of loads and generation to the DMS.

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A Solution Component: Incentivizing Dynamic Pricing

- Price signals can be issued in real-time, identifying a price for a given time interval, or based on energy price schedules that are published in advance.
- When solar generation makes up a large portion of a region's generation portfolio, unanticipated changes in cloud cover can unexpectedly change electricity supply
- Time-varying rates, and particularly dynamic rates that change hourly based on supply and demand, serve to send a price signal to customers
  - Rates rise in concert with supply reductions or increases in demand
  - Rates fall in concert with excess supply
  - Smart Meter–enabled customer energy management systems can work along with dynamic pricing, automatically managing air conditioning and appliance operation within a customer's pre-specified instructions as rates rise and fall.
  - This helps provide the flexibility required to reliably accommodate greater levels of renewable generation

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Locational Constraints Need to be Factored Into Dynamic Pricing

- Giving credit on a customer's power bill 1-for-1 between kilowatt-hours bought versus generated, net metering, is very simple as it assumes that the value of distributed generation equals the utility's current retail price
  - However, it completely ignores all locational differences and scale effects
    - It may be a good incentive policy but it is not a particularly accurate price signal
  - It also does not pay the utility for the infrastructure it built to in effect be a reliable battery.
- Customers will supply some of their own electricity service but will want to buy whatever they cannot self-produce from utility
  - However, customers who rely on the Ekurhuleni for all of their supply do not want to subsidize customers who sporadically rely on the electrical network only when they need it

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Paving the Way For Dynamic Pricing in the AMI Pilot Project

- In addition to being able to support dynamic pricing on a locational basis in the future without having to perform meter change-outs, this pilot project needs to learn information to collaborate with regulators and other stakeholders to optimize the dynamic pricing and demand control.
- This pilot will ensure that the technology and backend systems can support these future capabilities without requiring any major change-outs.
- Future pilots will leverage this technical capability to understand the degree to which customers respond to variations in pricing structures (i.e., the length of on-peak and off-peak periods, and pricing differentials).
- These objectives will require the ability to share meter information with the customer on a near real-time basis and to provide pricing signals to the customer.

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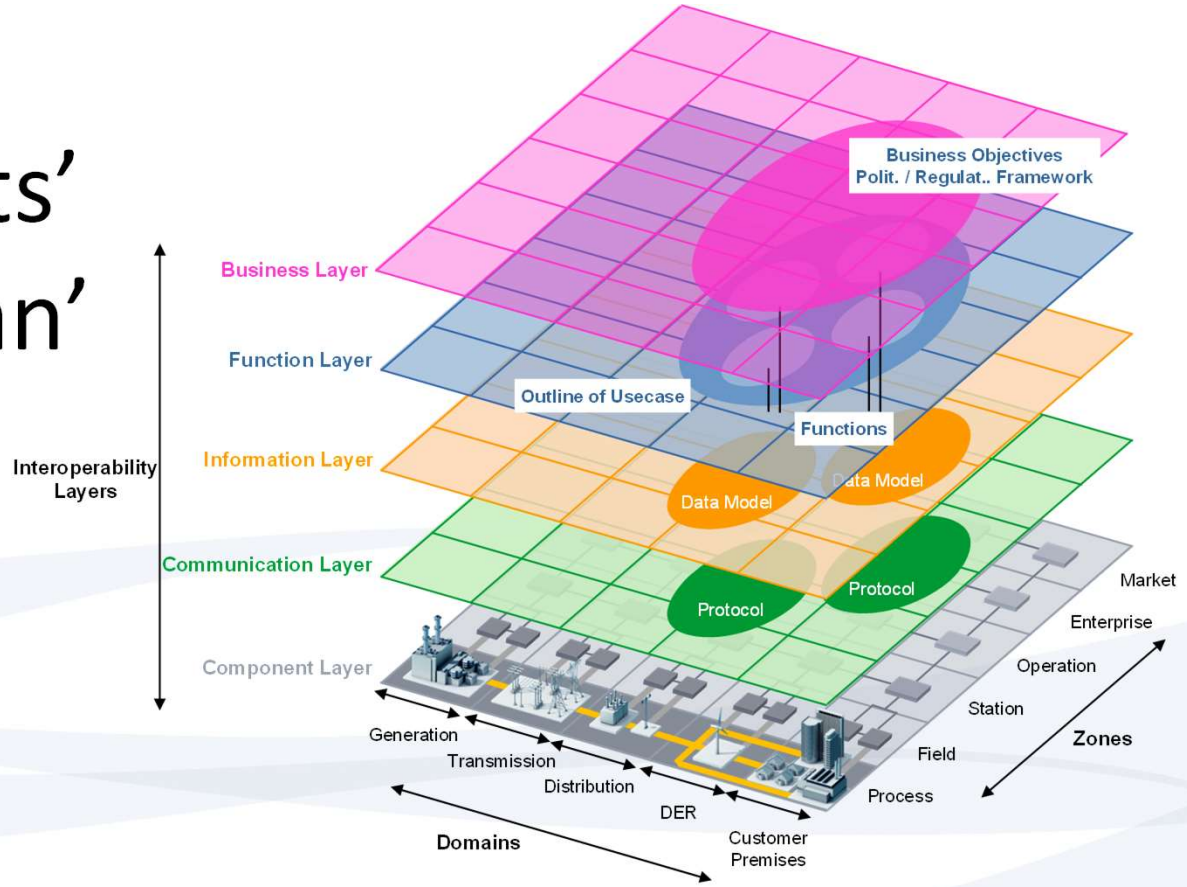
Implementing ‘Service Components’ Within a ‘Master Plan’



- Ekurhuleni, like most municipalities, needs an incremental “bottom-up” way of building its smart grid:
  - The Smart Grid Integration Framework (SGIF) is based on open industry standards
    - It enables services-driven automation to be implemented in step with business needs over the 20 year time horizon
    - Changes needed for a functional component will have minimal impact on other functional components
    - Each service can be owned/leased/operated or outsourced

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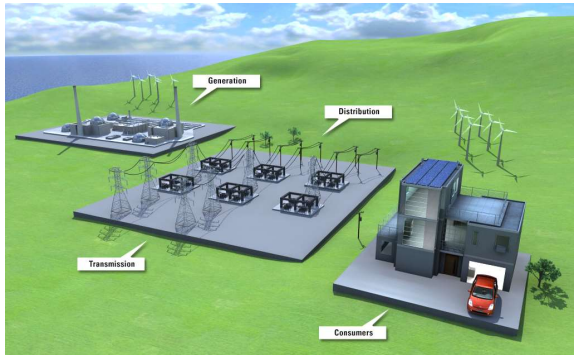
Conclusion



- PV is able to provide immediate positive benefit in the form of an off-grid solution to small households awaiting connections
  - Especially helpful for informal connections where various types of matters must be resolved before a traditional power connection can be made
- PV in the hands of an increasing number of medium and large customers will not be sustainable if “business as usual” continues into future years
- Ekurhuleni is embracing renewable energy, but must do so in a thoughtful way.
- Ekurhuleni has developed a Smart Grid Roadmap that includes a strategy for embracing PV solutions that will be beneficial to Ekurhuleni, its customers and stakeholders
- The first pilot project of the SG Roadmap will:
  - Provide smart metering that supports two way communications, including dynamic pricing
  - Be based on a flexible services-based integration infrastructure
    - The Smart Grid Integration Framework (SGIF) based on not only on open industry protocol standards, but industry standard data models
  - Yield useful learning so that Ekurhuleni and its stakeholders can make informed business model adjustment decisions (e.g., propose new tariffs that are sustainable)
- Following the Smart Grid Roadmap should enable Ekurhuleni to make investments in the near-term that will continue to be useful in the long-term
  - Avoid investing now in what will become a stranded investment later

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Final Thoughts

- One should take care to match the proposed solution to the expectations of the recipients…
- These expectations may sometimes be very different that which logic defines

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